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[ ] continuation patent application of
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Inventor(s)/Applicant Identifier: Bunsen Y. Wong et al.

For: MAGNETIC RECORDING MEDIA HAVING ADJUSTABLE COERCIVITY USING MULTIPLE MAGNETIC LAYERS AND METHOD OF MAKING SAME

Enclosed are:

[X] Return Receipt Postcard
[X] This Transmittal Letter (1 p in triplicate)
[X] 4 page(s) of specification and 1 title page
[X] 3 page(s) of claims
[X] 1 page of Abstract
[X] 5 sheet(s) of [ ] formal [X] informal drawing(s).
[X] Recordation Form Cover Sheet (1 p in duplicate)
[X] An assignment (3 pages) of the invention to Hyundai Electronics America
[X] A [X] signed [ ] unsigned Declaration & Power of Attorney (2 pages)

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TOTAL CLAIMS	20 - 20	= *0	x $9.00 =		OR	x $18.00 =	$0.00
INDEP. CLAIMS	3 - 3	= *0	x $39.00 =		OR	x $78.00 =	$0.00
[ ] MULTIPLE DEPENDENT CLAIM PRESENTED			+ $130.00 =		OR	+ $260.00 =	
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Respectfully submitted,
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PATENT APPLICATION

MAGNETIC RECORDING MEDIA HAVING ADJUSTABLE COERCIVITY USING MULTIPLE MAGNETIC LAYERS AND METHOD OF MAKING SAME

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MAGNETIC RECORDING MEDIA HAVING ADJUSTABLE COERCIVITY USING MULTIPLE MAGNETIC LAYERS AND METHOD OF MAKING SAME

BACKGROUND OF THE INVENTION

This invention relates generally to magnetic recording media such as magnetic thin film recording disks, and more particularly the invention relates to a method of varying coercivity of a recording medium using a multiple magnetic layer construction.

The magnetic disk drive as used for data storage in computer systems comprises one or more disks having thin film magnetic layers on opposing surfaces for the recording of magnetic data as bits along concentric tracks. Typically, as shown in Fig. 1 the disk comprises a substrate 4 of nickel phosphorus (NiP) or ceramic glass on which a plurality of layers are formed by sputtering in a low pressure inert gas atmosphere. The layers include an optional magnetic seed layer 6, a nonmagnetic underlayer 8 of either pure chromium (Cr) or a chrome alloy (CrX), covered by a magnetic layer 10 of a cobalt (Co) –based alloy. A protective layer 12 made of sputtered carbon (C) is typically used on top of the magnetic layer and an organic lubricant 14 may be used on top of the protective layer.

Data is recorded in the tracks on the disk surface by either vertical or longitudinal magnetization of the magnetic layer. Coercivity (Hr) is a measure of the magnetic field needed to switch polarization in the magnetic layer for the recording of magnetic data. A high magnetic coercivity is important to improve the recording parametric properties of the media and also to improve robustness against thermal decay of recorded information. The magnetic coercivity is controlled by a number of factors such as underlayer design, deposition conditions, and magnetic alloy selection. However, for a single film stack design, the three main parameters which can be used to enhance or reduce the coercivity are substrate temperature during sputtering (Fig. 2A), underlayer thickness (Fig. 2B), and substrate biasing when depositing the magnetic film (Fig. 2C).

Each of these parameters has limitations. As shown in Fig. 2A, while heater power and substrate temperature can increase coercivity, the remanence (Mrt) or magnetic flux density remaining after removal of applied magnitostrictive force decreases

with temperature. Additionally, excessive heat can crystallize the substrate. Thus, equipment and substrate constraints limit the use of high sputtering temperatures.

In Fig. 2B it will be noted that increasing the thickness of the underlayer asymptotically increases coercivity, while increasing underlayer thickness to raise coercivity also increases media noise. Fig. 2C shows that the use of substrate biasing for coercivity control has a minimal effect.

The present invention is directed to a method of adjusting coercivity which overcomes the limitations in the prior art techniques.

SUMMARY OF THE INVENTION

In accordance with the invention, a method of varying coercivity in the manufacture of a magnetic recording medium comprises the steps of providing a substrate for supporting a magnetic layer, sputtering on the substrate an underlayer having a lattice structure for matching with a magnetic layer lattice structure, sputtering a first magnetic layer on the underlying layer, the first magnetic layer having a first alloy composition, and sputtering at least a second magnetic layer on the first magnetic layer, the second magnetic layer having a second alloy composition different from the first alloy composition in percentage composition or element composition. By varying the relative thickness of the first magnetic layer to the thickness of the two magnetic layers, the coercivity of the multiple magnetic layers can be varied to a desired or optimum value.

In preferred embodiments, the overall thickness of the multiple magnetic layers is the same as the single magnetic layer in the prior art, and the magnetic layers comprise a mixture of cobalt (Co) with one or more other elements.

The invention and objects and features thereof will be more readily apparent from the following detailed description and appended claims when taken with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic illustrating the multiple layers in a conventional thin film recording medium.

Figs. 2A-2C are graphs illustrating the effects of substrate temperature, underlayer thickness, and electric bias on magnetic medium parameters.

Fig. 3 is a schematic of a multi-magnetic layer recording medium in accordance with one embodiment of the invention.

Figs. 4-7 are graphs illustrating the effects of relative magnetic film thicknesses on recording medium parameters in accordance with four embodiments of the invention.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

Fig. 3 is a schematic illustrating a magnetic recording medium having multiple magnetic layer thin films for recording data in accordance with a preferred embodiment of the invention. Again, a nickel phosphorus (NiP) or ceramic glass substrate 4 is provided on which a seed layer 6 is deposited with a chromium (Cr) or chrome alloy (CrX) layer 8 deposited on the seed layer. In accordance with the invention, two magnetic layers 10-1 and 10-2 are deposited by sputtering with a carbon (C) overcoat 12 and lubricant layer 14 being deposited over the magnetic layers. By using a multiple magnetic layer construction the media coercivity can be altered without changing substrate temperature, underlayer thickness, or substrate biasing as is necessary in the prior art.

Each magnetic layer consists of a magnetic alloy of different composition and intrinsic magnetic properties. When deposited individually under the same conditions, they exhibit different coercivity. When deposited in a multilayer structure, changing the thickness ratio between the two layers (see Figs. 4-7) can modify the coercivity. This can be represented by a thickness fraction Q of the first magnetic layer in the stack to the total multilayer thickness where

$$Q = \frac{t_{Mag1}}{\left(t_{Mag1+}t_{Mag2}\right)}$$

Importantly, the coercivity can be modified by varying Q while keeping the remanence, Mrt, constant. While the overall thickness of the multiple magnetic layers can be of the same thickness as a single layer prior art magnetic medium, the thickness of the individual magnetic layers can vary from 2 nm to 50 nm respectively.

The multi-magnetic layer structure can comprise cobalt alloys with different alloying elements including one or more of chromium, platinum, tantalum, boron, niobium, molybdenum, nickel, tungsten, carbon, aluminum, iron, and manganese.

As illustrated in the graphs of Figs. 4-7 for specific embodiments, by changing the relative thicknesses of the magnetic layers a change in coercivity is realized while keeping remanence, deposition conditions, and underlayer thickness constant. An

optimum coercivity can be realized solely by the variation in thicknesses of the magnetic layers.

In Fig. 4 the effect of film fraction Q on coercivity (Hr), remanence (Mrt) and coercive squareness (S*) are illustrated for a first layer of Co-20Cr-10Pt-8B and a second layer of Co-22Cr-10Pt-6B. Coercivity is given in kiloOersterd (kOe) while remanence and coercive squareness are given in relative units.

In Fig. 5 the first magnetic layer is Co-20Cr-10Pt-8B and the second layer is Co-26Cr-10Pt-6B, while in Fig. 6 the first magnetic layer is an alloy of Co-20CR-10Pt-8B and the second layer is Co-20Cr-8 Pt-4Ta. In Fig. 7 the first magnetic layer is Co-20Cr-8Pt-4Ta and the second magnetic layer is Co-18Cr-6Pt-3Ta. In each of the figures it will be noted that varying the ratio Q has a significant effect on coercivity with little or no effect on remanence and sharpness.

While the invention has been described with reference to specific embodiments, the description is illustrative of the invention and is not to be construed as limiting the invention. For example, while two magnetic layers are described in each of the embodiments , more than two magnetic layers can be employed. Thus, various modifications and applications may occur to those skilled in the art without departing from the true spirit and scope of the invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. In the manufacture of a magnetic recording medium, a method of varying coercivity comprising the steps of

a) providing a substrate for supporting magnetic layers,

b) sputtering on the substrate an underlayer having a lattice structure for matching with a magnetic layer lattice structure,

c) sputtering a first magnetic layer on the underlayer, the first magnetic layer having a first alloy composition, and

d) sputtering a second magnetic layer on the first magnetic layer, the second magnetic layer having a second alloy composition which differs from the first alloy composition, whereby coercivity of the two magnetic layers is determined by the relative thicknesses of the two magnetic layers.

2. The method as defined by claim 1 wherein steps c) and d) form magnetic layers each having a thickness in the range of 2 nm – 50 nm.

3. The method as defined by claim 2 wherein each of the two magnetic layers comprise a cobalt alloy with at least one of chromium, platinum, tantalum, boron, niobium, molybdenum, nickel, tungsten, carbon, aluminum, iron, and manganese.

4. The method as defined by claim 3 wherein step c) forms a first magnetic layer having an alloy composition of Co-20Cr-10Pt-8B, and step d) forms a second magnetic having a composition of Co-22Cr-10Pt-6B.

5. The method as defined by claim 3 wherein step c) forms a first magnetic layer having a composition of Co-20Cr-10Pt-8B, and step d) forms a second magnetic layer having a composition of Co-26Cr-10Pt-6B.

6. The method as defined by claim 3 wherein step c) forms a first magnetic layer having a composition of Co-20Cr-10Pt-8B, and step d) forms a second magnetic layer having a composition of Co-20Cr-8Pt-4Ta.

7. The method as defined by 3 wherein step c) forms a first magnetic layer having an alloy composition of Co-20Cr-8Pt-4Ta and step d) forms a second magnetic layer having an alloy composition of Co-18Cr-6Pt-3Ta.

8. The method as defined by claim 3 wherein step b) comprises sputtering an underlying layer including chromium or a chrome alloy.

9. The method as defined by claim 8 wherein step a) includes providing a substrate selected from nickel phosphorus and ceramic glass.

10. The method as defined by claim 1 and further including a step e) of sputtering a third magnetic layer on the second magnetic layer.

11. A magnetic recording medium comprising

a substrate,

an underlayer supported by the substrate,

a first magnetic layer on the underlayer, said first magnetic layer having first alloy composition, and

a second magnetic layer on the first magnetic layer, the second magnetic layer having a second alloy composition which differs from the first alloy composition whereby coercivity of the two magnetic layers is determined by relative thickness of the first magnetic layer to the thickness of the two magnetic layers.

12. The magnetic recording medium as defined by claim 11 wherein the thickness of each magnetic layer is between 2 nm and 50 nm.

13. The magnetic recording medium as defined by claim 11 wherein each of the two magnetic layers comprise an alloy of cobalt with at least one of chromium, platinum, tantalum, boron, niobium, molybdenum, nickel, tungsten, carbon, aluminum, iron, and manganese.

14. The magnetic recording medium as defined by claim 13 wherein the first magnetic layer comprises an alloy having a composition of Co-20Cr-10Pt-8B and the second magnetic layer comprises an alloy having a composition of Co-22Cr-10Pt-6B.

15. The magnetic recording medium as defined by claim 13 wherein the first magnetic layer comprises an alloy having a composition of Co-20Cr-10Pt-8B, and the second magnetic layer comprises an alloy having a composition of Co-26Cr-10Pt-6B.

16. The magnetic recording medium as defined by claim 13 wherein the first magnetic layer comprises an alloy having a composition of Co-20Cr-10Pt-8B, and the second magnetic layer comprising an alloy having a composition of Co-20CR-8Pt-4Ta.

17. The magnetic recording medium as defined by claim 13 wherein the first magnetic layer comprises an alloy having a composition of Co-20Cr-8Pt-4Ta, and the second magnetic layer comprising an alloy having a composition of CO-18Cr-6Pt-3Ta.

18. The magnetic recording medium as defined by claim 11 wherein the substrate is selected from nickel phosphorus and ceramic glass, and the underlayer is selected from chromium and chrome alloy.

19. The magnetic recording medium as defined by claim 18 and further including a seed layer between the underlayer and the substrate, a carbon overcoat layer over the second magnetic layer, and a lubricant layer on the carbon overcoat layer.

20. A method for establishing the coercivity of magnetic recording material on a substrate comprising the steps of providing a substrate and at least two cobalt based alloy magnetic layers sputtered in sequence on the substrate with the relative thicknesses of the two magnetic layers determining coercivity.

MAGNETIC RECORDING MEDIA HAVING ADJUSTABLE COERCIVITY USING MULTIPLE MAGNETIC LAYERS AND METHOD OF MAKING SAME

ABSTRACT OF THE DISCLOSURE

The coercivity of a magnetic recording medium such as a magnetic disk is determined by providing at least two magnetic layers in the recording medium with the relative thicknesses of the two magnetic layers determining coercivity without the need for changing substrate temperature, underlayer thickness or substrate biasing during manufacture. Each magnetic layer is a cobalt alloy of different composition and intrinsic magnetic properties. Importantly, the coercivity can be modified without adversely affecting remanence or squareness of the hysteresis transition region for the recording medium.

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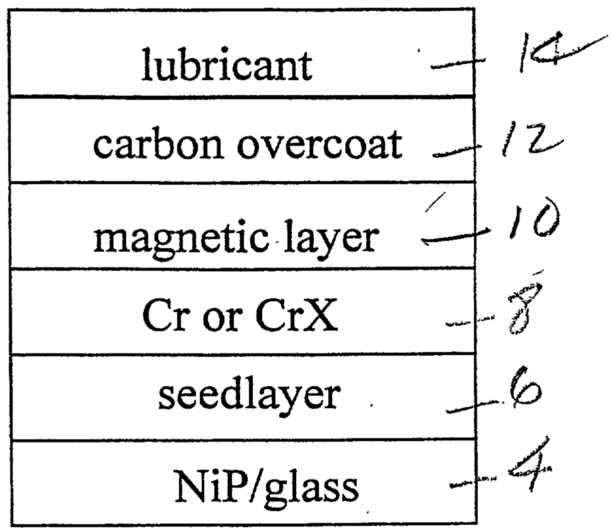

Figure 1. Schematic of a normal thin film disk construction.

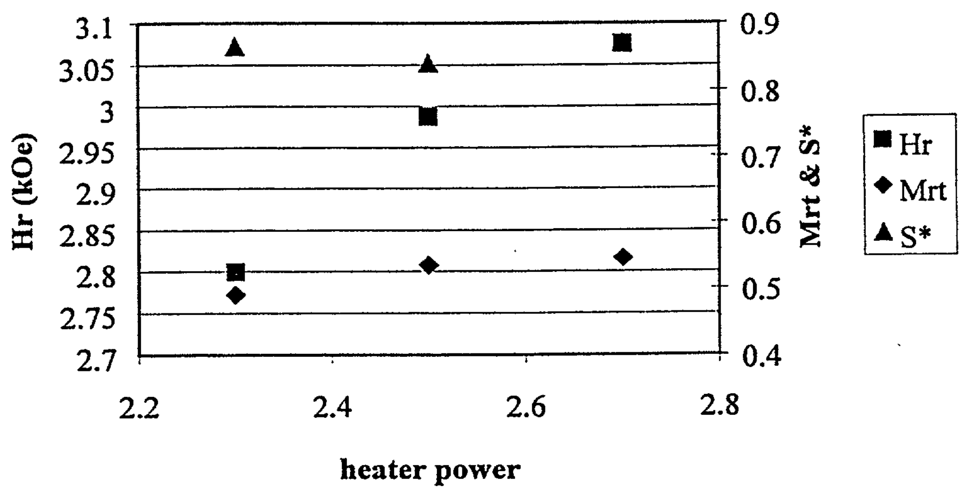

Figure 2a. Effect of Substrate Heater power on Hr, Mrt and S*.

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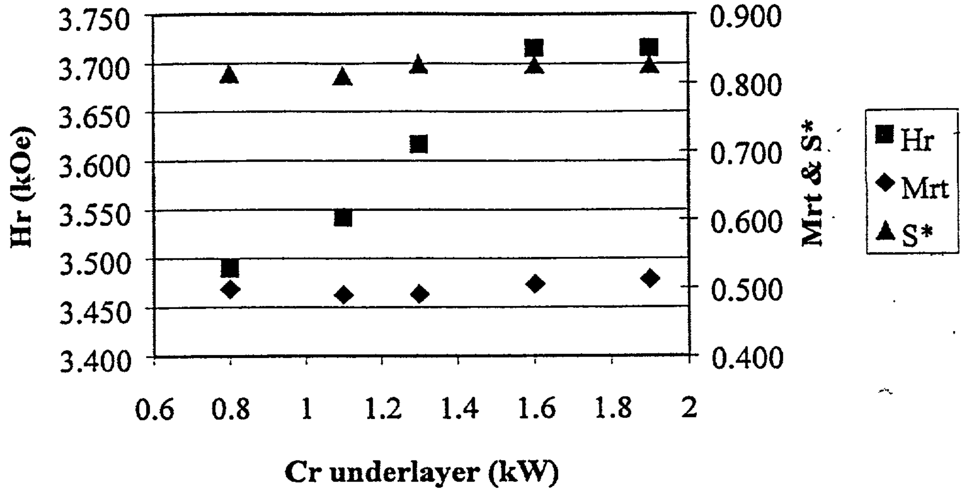

Figure 2b. Effect of Cr underlayer thickness on Hr, Mrt and S*.

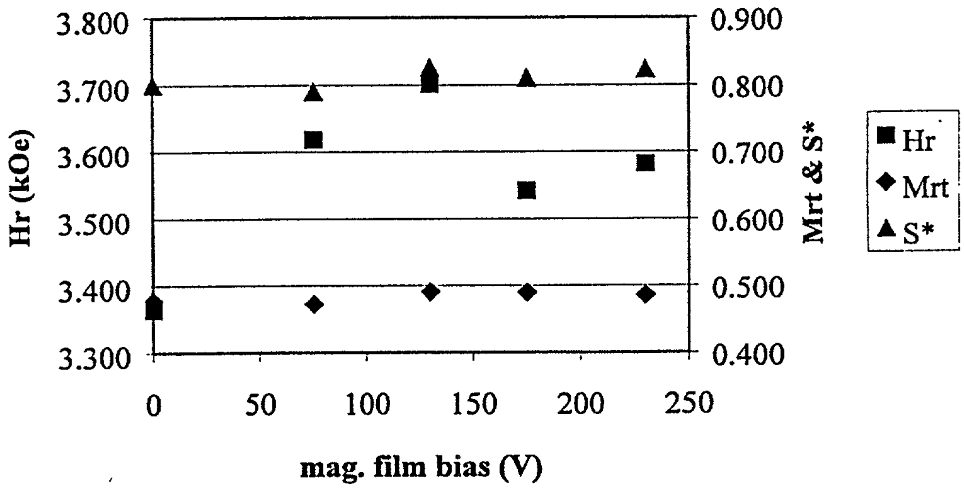

Figure 2c. Effect of magnetic film bias on Hr, Mrt and S*.

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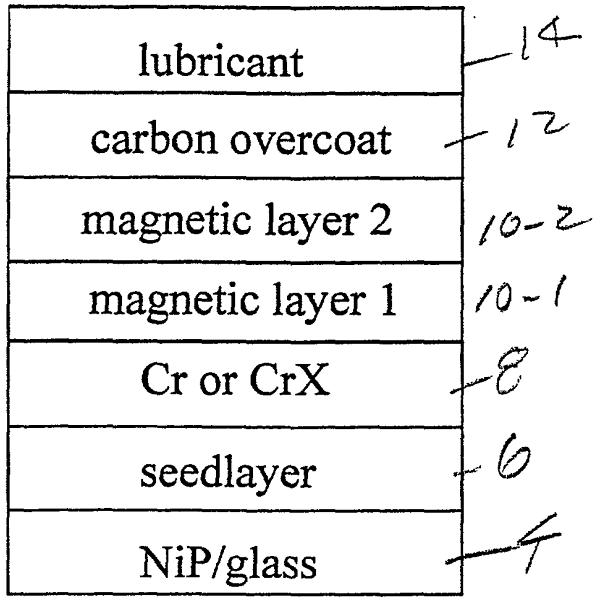

Figure 3. Schematic of a multi-magnetic layer thin film disk construction.

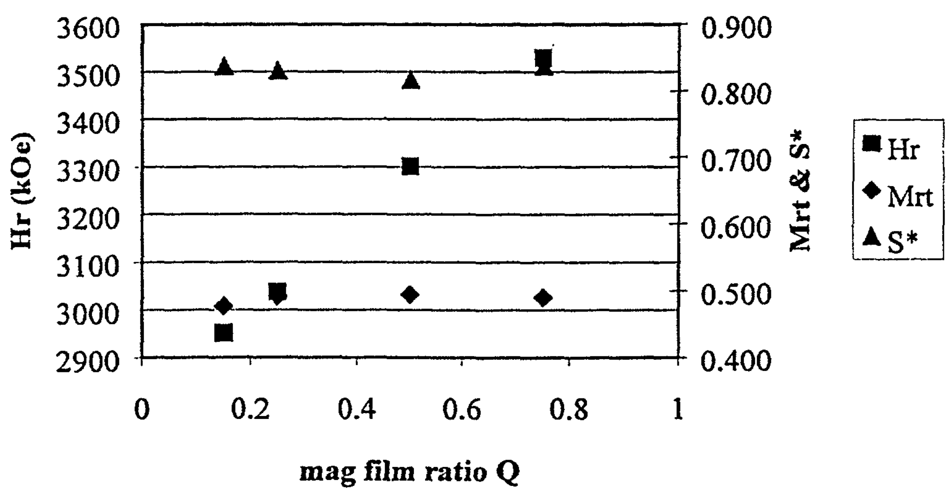

Figure 4. Effect of film fraction Q on Hr, Mrt and S* of CoCrPtB/CoCrPtB multi-magnetic layer media.

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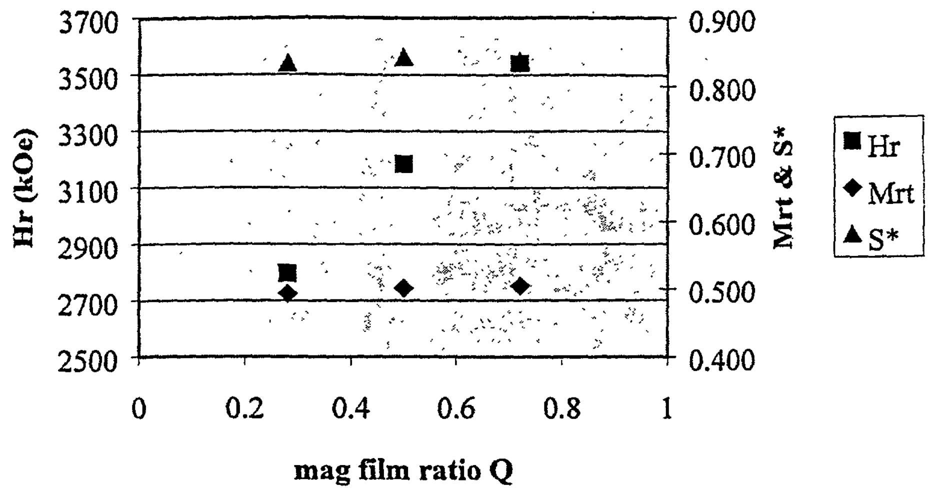

Figure 5. Effect of film fraction Q on Hr, Mrt and S* of a CoCrPtB/CoCrPtB multi-magnetic layer media.

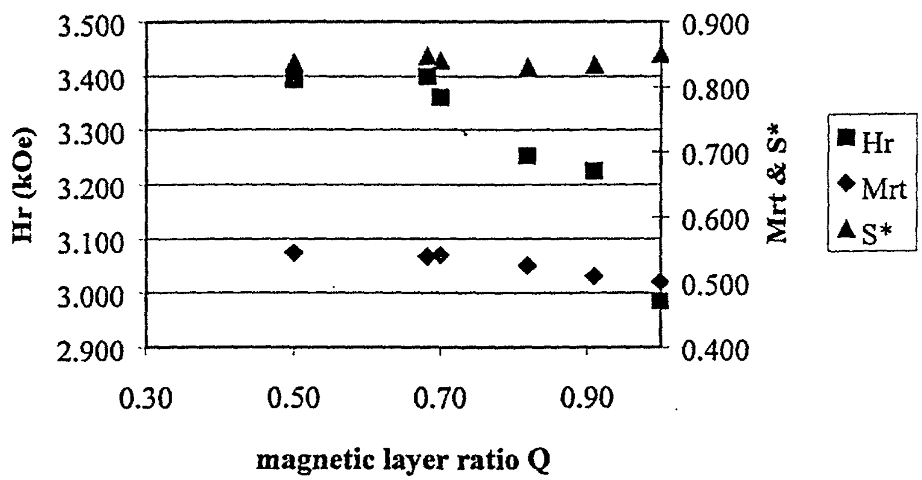

Figure 6. Effect of film fraction Q on Hr, Mrt and S* of a CoCrPtB/CoCrPtTa multi-magnetic layer media.

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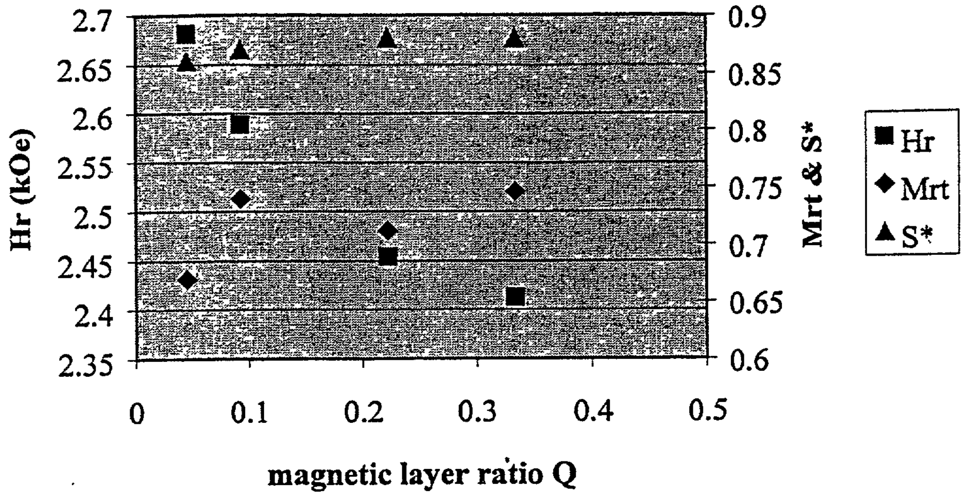

Figure 7. Effect of film fraction Q on Hr, Mrt and S* of a CoCrTaPt/CoCrTa multi-magnetic layer media.

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I declare that:

My residence, post office address and citizenship are as stated below next to my name; I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: **MAGNETIC RECORDING MEDIA HAVING ADJUSTABLE COERCIVITY USING MULTIPLE MAGNETIC LAYERS AND METHOD OF MAKING SAME** the specification of which _X_ is attached hereto or ____ was filed on ______________ as Application No. ______________ and was amended on ______________ (if applicable).

I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56. I claim foreign priority benefits under Title 35, United States Code, Section 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Country	Application No.	Date of Filing	Priority Claimed Under 35 USC 119

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below:

Application No.	Filing Date

I claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Application No.	Date of Filing	Status

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

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I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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BUNSEN Y. WONG	BING ZHANG	KENNETH E. JOHNSON
Date 14th April, 2000.	Date 5-2-00	Date 5-2-00

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